



The **fx-991EX** "ClassWiz" features a high-resolution display, making it easier to view formulas and symbols.

This remarkable screen can display between 2-6 times as many characters as other scientific calculators, yet still runs on solar power.

Use the **ON** key to turn the calculator on, and press **SHIFT AC** (OFF) to power the unit down.

The icon-based menu, accessible via the **MENU** key, allows easy navigation of features using the arrow keys and the number keys or the **ALPHA** shortcuts.

The **DEL** key can be used like Backspace in a word processor to delete the character(s) left of the cursor.

The symbols printed on the keys use Natural Textbook Display™ notation, similar to that found in textbooks. This makes input of expressions fast and easy.

The **S/D** key toggles your calculation results between Standard (exact) and Decimal forms.

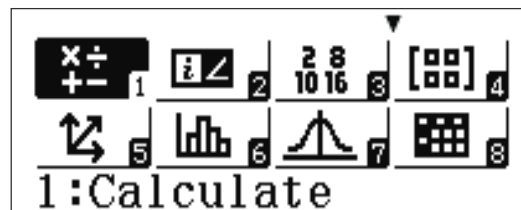
The following explains the meaning of each icon on the fx-991EX icon menu

Icon	Menu Name	Description
	<b>CALCULATE</b>	Perform general computations using Natural Textbook Display™ notation, including absolute value, logs of any base, summation, derivatives, and integrals.
	<b>COMPLEX</b>	Perform computations with complex numbers, including $a + bi$ form, polar ( $r\angle\theta$ ) form, and conversions between the two.
	<b>BASE-N</b>	Perform binary, octal, and hexadecimal computations, and convert among those number bases and base-10.
	<b>MATRIX</b>	Perform operations on matrices up to 4x4, including matrix arithmetic, determinants, transpositions, and identity matrices.
	<b>VECTOR</b>	Perform operations on 2- and 3-dimensional vectors, including vector arithmetic, dot products, angles, and unit vectors.
	<b>STATISTICS</b>	Calculate 13 different one-variable statistics, and apply linear, quadratic, logarithmic, exponential, and geometric (power) regressions.
	<b>DISTRIBUTION</b>	Investigate Normal, Inverse Normal, Binomial, and Poisson probability and cumulative distributions.
	<b>SPREADSHEET</b>	Create spreadsheets with up to 5 columns and 45 rows. Spreadsheet supports Fill, Cut/Copy/Paste, recursive formulas, Mean, and Sum commands.
	<b>TABLE</b>	Create tables of values to compare up to 2 functions simultaneously.
	<b>EQUATION/ FUNCTION</b>	Solve simultaneous (systems of) equations with up to 4 unknowns, and polynomials of up to degree 4.
	<b>INEQUALITY</b>	Solve polynomial inequalities of up to degree 4, with the solution set expressed as a compound inequality.
	<b>RATIO</b>	Solve proportions of the form $A : B = X : D$ and $A : B = C : X$ .

# CALCULATE

Below are some examples of the Natural Textbook Display™ input/output notation, as found by selecting the Calculate icon from the Main Menu of the **fx-991EX**.

From the Main Menu, use the arrow keys to highlight the Calculate icon, then press  $\boxed{=}$  or press  $\boxed{1}$ .



Fractions and mixed numbers can be entered using  $\boxed{\frac{\Box}{\Box}}$  and  $\boxed{\text{SHIFT}} \boxed{\frac{\Box}{\Box}} (\text{a}\frac{\text{b}}{\text{c}})$ , respectively.

To enter the calculation to the left, press

$\boxed{\frac{\Box}{\Box}} \boxed{7} \boxed{\rightarrow} \boxed{8} \boxed{\rightarrow} \boxed{+} \boxed{\text{SHIFT}} \boxed{\frac{\Box}{\Box}} (\text{a}\frac{\text{b}}{\text{c}}) \boxed{2} \boxed{\rightarrow} \boxed{3} \boxed{\rightarrow} \boxed{1} \boxed{1} \boxed{=}$ .

$$\frac{7}{8} + 2\frac{3}{11} = \frac{277}{88}$$

To change the solution to a decimal format, press  $\boxed{\text{S}\rightarrow\text{D}}$ .

$$\frac{7}{8} + 2\frac{3}{11} = 3.147727273$$

Press  $\boxed{\text{SHIFT}} \boxed{\text{S}\rightarrow\text{D}} (\text{a}\frac{\text{b}}{\text{c}} \leftrightarrow \frac{\text{a}}{\text{c}})$  to convert the result into a mixed-number format.

$$\frac{7}{8} + 2\frac{3}{11} = 3\frac{13}{88}$$

When inputting radical expressions, the radical bar automatically extends as additional characters are typed.

Press  $\boxed{\sqrt{\Box}} \boxed{2} \boxed{4} \boxed{=}$ .

$$\sqrt{24} = 2\sqrt{6}$$

The output will be displayed in simplest radical form, but can be converted into a decimal approximation by pressing  $\boxed{\text{S}\rightarrow\text{D}}$ .

$$\sqrt{24} = 4.898979486$$

# CALCULATE

ClassWiz is capable of recognizing and combining like radicals.

Press  $\sqrt{\square}$   $2$   $4$   $\rightarrow$   $+$   $\sqrt{\square}$   $1$   $5$   $0$   $=$ .

$$\sqrt{24} + \sqrt{150} = 7\sqrt{6}$$

It can also calculate unlike radicals. Press

$\sqrt{\square}$   $2$   $4$   $\rightarrow$   $-$   $\sqrt{\square}$   $9$   $8$   $=$ .

$$\sqrt{24} - \sqrt{98} = 2\sqrt{6} - 7\sqrt{2}$$

Higher-order radicals can be beautifully expressed using Natural Textbook Display™ input.

Press  $\text{SHIFT}$   $x^{\square}$  ( $\sqrt{\square}$ )  $5$   $\rightarrow$   $6$   $4$   $=$ .

$$\sqrt[5]{64} = 2.29739671$$

Natural Textbook Display™ templates can be stacked inside one another to allow input of complicated expressions such as this quotient of rational exponentials.

Press  $\frac{\square}{\square}$   $3$   $x^{\square}$   $\frac{\square}{\square}$   $1$   $\rightarrow$   $2$   $\rightarrow$   $\rightarrow$   $\rightarrow$   $3$   $x^{\square}$   $-$   $2$   $=$ .

$$\frac{3^{\frac{1}{2}}}{3^{-2}} = 15.58845727$$

(Note: the calculator does not generate a Syntax Error when the  $-$  key is used to create a negative sign. Both  $-$  and  $\text{(-)}$  are acceptable for use.)

In a trigonometry setting, arithmetic can be performed in

terms of  $\pi$ . Press  $\frac{\square}{\square}$   $3$   $\text{SHIFT}$   $\times 10^{\square}$  ( $\pi$ )  $\rightarrow$   $4$   $\rightarrow$   $+$   $2$   $\text{SHIFT}$   $\times 10^{\square}$  ( $\pi$ )  $=$ .

$$\frac{3\pi}{4} + 2\pi = \frac{11}{4}\pi$$

Other useful Natural Textbook Display™ templates that help overcome typical calculator input frustrations include: logarithms of any base,

$\log_{\square}$   $\frac{\square}{\square}$   $1$   $\rightarrow$   $2$   $\rightarrow$   $\rightarrow$   $1$   $6$   $=$

$$\log_{\frac{1}{2}}(16) = -4$$

# CALCULATE

...summation (sigma) notation,

$\boxed{\text{SHIFT}} \boxed{x} \boxed{\left(\sum\right)} \boxed{x} \boxed{x^2} \boxed{+} \boxed{1} \boxed{\rightarrow} \boxed{-} \boxed{3} \boxed{\rightarrow} \boxed{7} \boxed{=}$

$$\sum_{x=-3}^7 (x^2+1) = 165$$

...derivatives of a function at a specific point (value),

$\boxed{\text{SHIFT}} \boxed{\left(\frac{d}{dx}\right)} \boxed{4} \boxed{x} \boxed{x^2} \boxed{-} \boxed{5} \boxed{x} \boxed{\rightarrow} \boxed{0} \boxed{\cdot} \boxed{2} \boxed{=}$

$$\frac{d}{dx} (4x^2 - 5x) \Big|_{x=0.2} = -\frac{17}{5}$$

...and definite integrals.

$\boxed{\int} \boxed{1} \boxed{\rightarrow} \boxed{x} \boxed{\rightarrow} \boxed{2} \boxed{\rightarrow} \boxed{5} \boxed{=}$ .

$$\int_2^5 \frac{1}{x} dx = 0.9162907319$$

Settings for the “Calculate” mode can be accessed by pressing

$\boxed{\text{SHIFT}} \boxed{\text{MENU}} \text{ (SET UP)}$ .

Press  $\boxed{\blacktriangledown}$  one or more times to reveal additional Setup options.

1: Input/Output  
2: Angle Unit  
3: Number Format  
4: Engineer Symbol

1: Fraction Result  
2: Complex  
3: Statistics  
4: Spreadsheet

1: Equation/Func  
2: Table  
3: Decimal Mark  
4: Digit Separator

1: MultiLine Font  
2: QR Code  
3: Contrast

## SOLVE

The **fx-991EX** can elegantly solve an equation for any unknown using Newton's method with the SOLVE command. To use SOLVE, first input the equation to be solved, then press  $\boxed{\text{SHIFT}} \boxed{\text{CALC}} \text{ (SOLVE)}$ .

Solve  $x^2 + Ax + Bx = 0$  for  $x$  when  $A = 5$  and  $B = 6$ .

Enter the equation by pressing,  $\boxed{x} \boxed{x^2} \boxed{+} \boxed{\text{ALPHA}} \boxed{(\leftarrow)} \text{ (A)}$

$\boxed{x} \boxed{+} \boxed{\text{ALPHA}} \boxed{(\rightarrow)} \text{ (B)} \boxed{\text{ALPHA}} \boxed{\text{CALC}} \boxed{=} \boxed{0}$ .

$$x^2 + Ax + B = 0$$

$$x = -5$$

# CALCULATE

Input an initial guess for  $x$  followed by the values of  $A$  and  $B$ .  
Press **SHIFT** **CALC** (SOLVE) **=** **5** **=** **5** **=** **6** **=**.

Arrow back up to **x=** and SOLVE the equation by pressing **=**.

To accomplish the same task and solve for  $A$  or  $B$ , enter a value for  $x$  and a value for one of the other unknowns.

For example, to solve for  $A$  when  $x = 1$  and  $B = 4$ , press **SHIFT** **CALC** (SOLVE) **1** **=** **2** **=** **4** **=**.

Arrow back up to **A=** and SOLVE the equation by pressing **=**.

The solution also displays  $L - R = 0$ . This means that Newton's method of approximation is directly on  $-5$ . If  $L - R$  is not 0, simply recalculate to get a better approximation.

$$x^2 + Ax + B = 0$$

$$A = 5$$

$$x^2 + Ax + B = 0$$

$$B = 6$$

$$x^2 + Ax + B = 0$$

$$x =$$

$$L - R = -3$$

$$0$$

$$x^2 + Ax + B = 0$$

$$x = 1$$

$$x^2 + Ax + B = 0$$

$$B = 4$$

$$x^2 + Ax + B = 0$$

$$A = 2$$

$$x^2 + Ax + B = 0$$

$$A =$$

$$L - R = -5$$

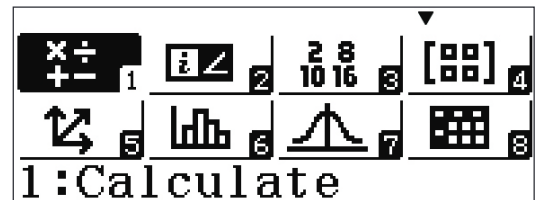
$$0$$

# CALCULATE

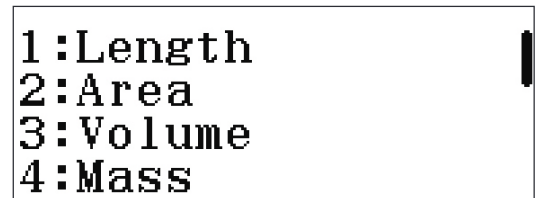
## ENGINEERING CALCULATIONS

There are many menus in the **fx-991EX** that can handle engineering calculations. The **fx-991EX** has the power to handle vectors, matrices, complex numbers and numerically calculates summation and even definite integrals.

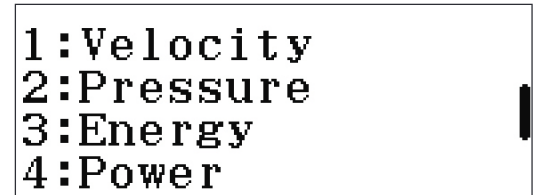
From the Main Menu, use the arrow keys to highlight the Calculate icon and press **≡** or press **1**.



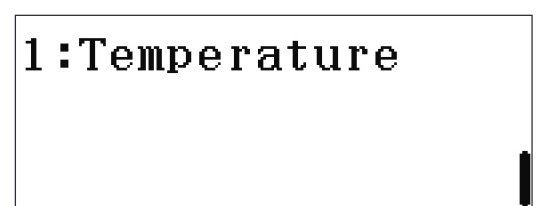
There are many different types of unit conversions that can be accomplished on this menu. To view the options, press **SHIFT** **8** (CONV). Use the down arrow key (**▼**) to see all the possibilities.



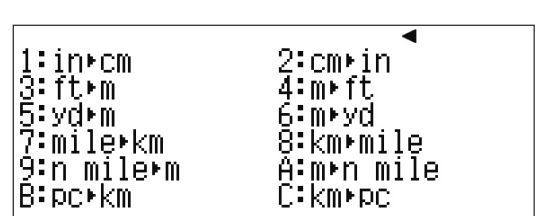
Each one of the choices has a wide range of conversion options for many different types of unit conversion.



Use the arrow keys to locate the Length conversion and press **1**.



To convert 500 inches (in) into centimeters (cm), press **AC** to return to the initial Calculate screen.



Press **5** **0** **0** **SHIFT** **8** (CONV) **1** (Length) **1** (in ► cm) **≡**.



# CALCULATE

To find the difference between one US Gallon and one UK Gallon, first, convert to a common unit, like a liter (L).

Press **1** **SHIFT** **8** (CONV) **3** (Volume) **1** (gal(US) ► L) **=**.

One US gallon is approximately 3.785 L.  
Now, convert the solution to gallons UK.

Press **SHIFT** **8** (CONV) **3** (Volume) **4** (L ► gal(UK)) **=**.

It looks like a US gallon is smaller.

1 US gallon = 0.8326742321 UK gallons.

The same calculation can be accomplished using a string of conversions.

Press **1** **SHIFT** **8** (CONV) **3** (Volume) **1** (gal(US) ► L) **SHIFT** **8** (CONV) **3** (Volume) **4** (L ► gal(UK)) **=**.

## ENGINEERING NOTATION

Converting large numbers into scientific and engineering notations can be accomplished through a short series of keystrokes.

Start with a large number like  $2.5 \times 10^9$ .

Press **2** **.** **5**  **$\times 10^x$**  **9** **=**.

The gap between digits at place value separation can be viewed by entering Set Up. Press **SHIFT** **MENU** (SET UP) and use the arrow keys to navigate to the third menu.

```
1:gal(US)►L      2:L►gal(US)
3:gal(UK)►L      4:L►gal(UK)
```

```
1gal√D(US)►L      ▲
3.785412
```

```
AnsL√D►gal(UK)      ▲
0.8326742321
```

```
1gal√D(US)►LL►gal(UK)      ▲
0.8326742321
```

```
2.5√D×109      ▲
2500000000
```

```
1:Equation/Func
2:Table
3:Decimal Mark
4:Digit Separator
```



# CALCULATE

Press **[4]** (Digit Separator) **[1]** (On) to turn on the Digit Separator to show separation between place values.

Digit Separator?  
1:On  
2:Off

Press **[=]** to recalculate the result and display clear place value separation.

$2.5 \times 10^9$   
2 500 000 000

To convert this solution into engineering notation, use the **[ENG]** key to change the solution into scientific notation. To move the decimal to the right, press **[ENG]**.

$2.5 \times 10^9$   
 $2.5 \times 10^9$

$2.5 \times 10^9$   
 $2500 \times 10^6$

$2.5 \times 10^9$   
 $2500000 \times 10^3$

$2.5 \times 10^9$   
 $2500000000 \times 10^0$

To move the decimal to the left, press **[SHIFT]** **[ENG]** (**←**).

$2.5 \times 10^9$   
 $2500000 \times 10^3$

Calculating with engineering symbols has never been easier.

To turn on the engineering symbols in setup, press **[SHIFT]** **[MODE]** (SET UP).

1:Input/Output  
2:Angle Unit  
3:Number Format  
4:Engineer Symbol

Select **[4]** (Engineer Symbol) **[1]** (On) to turn on the Engineering Symbols.

Engineer Symbol?  
1:On  
2:Off

# CALCULATE

To calculate 500k (kilo) + 10M (Mega), press

**5** **0** **0** **OPTN** **3** (Engineering Symbols)

**6** (k) **+** **1** **0** **OPTN** **3** (Engineering Symbols)

**7** (M) **=**.

The solution is displayed using the appropriate units.

Now, use the **ENG** key to convert between units.

500k+10M  
10 500 000

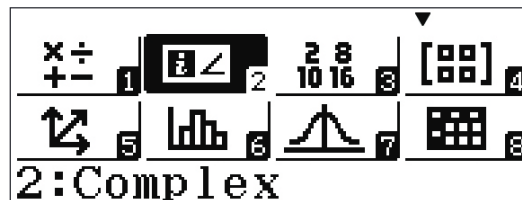
500k+10M  
10.5M

500k+10M  
10 500k

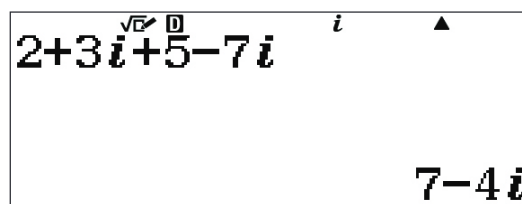
# COMPLEX

Complex Number calculations can be executed in the Complex Mode.

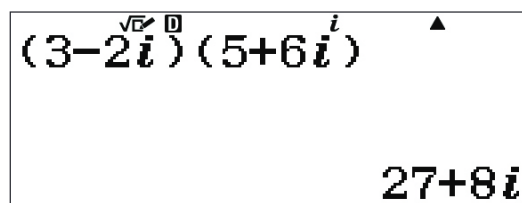
From the Main Menu, use the arrow keys to highlight the Complex icon, then press  $\equiv$  or press  $\boxed{2}$ .



In Complex Mode, operations can be carried out using the imaginary unit ( $i$ ). To add complex numbers, press  $\boxed{2} \boxed{+} \boxed{3} \text{ENG} (i) \boxed{+} \boxed{5} \boxed{-} \boxed{7} \text{ENG} (i) \boxed{\equiv}$ .

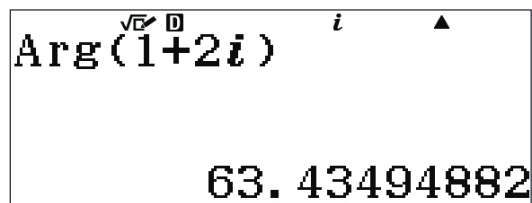
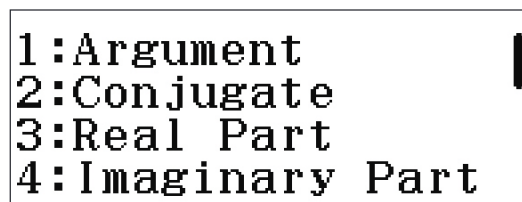


Complex numbers that are multiplied are displayed in complex format. Press  $\boxed{(\boxed{3} \boxed{-} \boxed{2} \text{ENG} (i) \boxed{)} \boxed{(\boxed{5} \boxed{+} \boxed{6} \text{ENG} (i) \boxed{)} \boxed{\equiv}}$ .



The argument of the complex number  $1+2i$ , can be found by taking the arctan ( $y/x$ ) =  $63.4349^\circ$  or by using the Argument command.

Press  $\boxed{\text{OPTN}} \boxed{1} \text{(Argument)} \boxed{1} \boxed{+} \boxed{2} \text{ENG} (i) \boxed{)} \boxed{\equiv}$



## COMPLEX FORM AND POLAR FORM

To convert a complex number into polar form, press

$\boxed{2} \boxed{+} \boxed{5} \boxed{\text{ENG}} \boxed{(i)} \boxed{\text{OPTN}} \boxed{\blacktriangledown} \boxed{1} \boxed{\blacktriangleright r\angle} \boxed{=}$ .

1:  $\blacktriangleright r\angle\theta$   
2:  $\blacktriangleright a+bi$

To convert any polar form of a complex number, use the r theta command or type in the angle in polar form.

Press  $\boxed{\text{AC}} \boxed{2} \boxed{\text{SHIFT}} \boxed{\text{ENG}} \boxed{(\angle)} \boxed{3} \boxed{3} \boxed{0} \boxed{\text{OPTN}} \boxed{\blacktriangledown}$

$\boxed{2} \boxed{\blacktriangleright a+bi} \boxed{=}$ .

Alternately, simply type in the angle in polar form by pressing

$\boxed{2} \boxed{\text{SHIFT}} \boxed{\text{ENG}} \boxed{(\angle)} \boxed{3} \boxed{3} \boxed{0} \boxed{=}$ .

These calculations can also be accomplished in radian mode.

To change to radian mode, press  $\boxed{\text{SHIFT}} \boxed{\text{MENU}} \boxed{(\text{SET UP})} \boxed{2} \boxed{(\text{Angle Unit})} \boxed{2} \boxed{(\text{Radian})}$ .

2+5 $i$   $\blacktriangleright r\angle\theta$   
 $\sqrt{29} \angle 68.19859051$

2 $\angle 330$   $\blacktriangleright a+bi$   
 $\sqrt{3}-i$

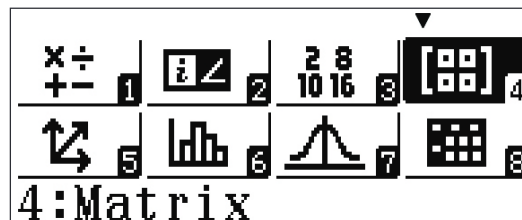
2 $\angle 330$   
 $\sqrt{3}-i$

2 $\angle \frac{11}{6}\pi$   
 $\sqrt{3}-i$

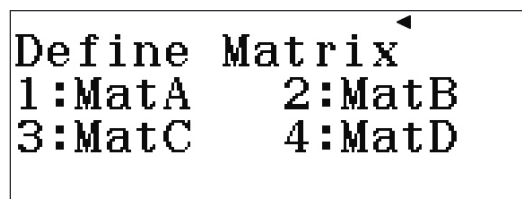
# MATRIX

Operations with matrices and matrix related calculations are all located in the Matrix Menu.

From the Main Menu, use the arrow keys to highlight the Matrix icon and press  $\equiv$  or press  $\boxed{4}$ .

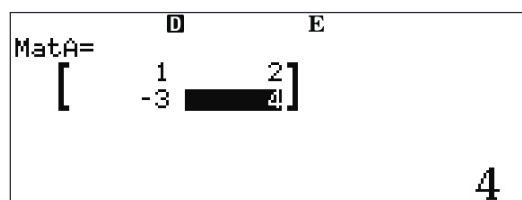


To enter matrices, first, define the matrix.

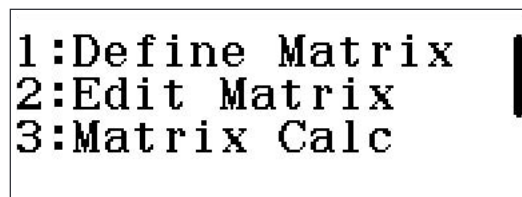


Press  $\boxed{1}$  (MatA)  $\boxed{2}$  (Rows)  $\boxed{2}$  (Columns)

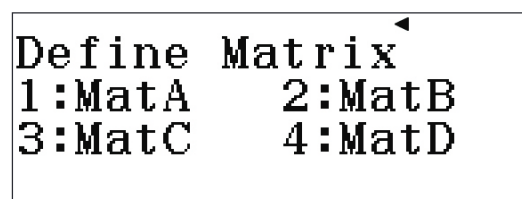
$\boxed{1} \equiv \boxed{2} \equiv \boxed{\rightarrow} \boxed{3} \equiv \boxed{4} \equiv$ .



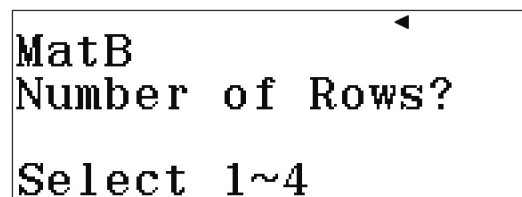
To enter a second matrix, press  $\boxed{\text{OPTN}}$ .



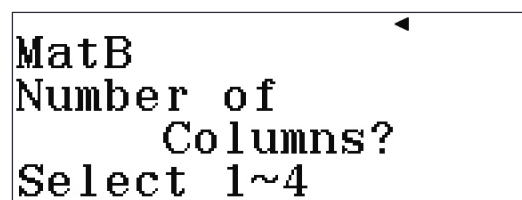
From the resulting popup window, press  $\boxed{1}$  (Define Matrix)  $\boxed{2}$  (MatB).



Select the number of rows,  $\boxed{2}$  (Rows).



Select the number of columns,  $\boxed{2}$  (Columns).



# MATRIX

Enter the matrix values by pressing

$\boxed{3} \boxed{=}$   $\boxed{(-)} \boxed{6} \boxed{=}$   $\boxed{8} \boxed{=}$   $\boxed{2} \boxed{=}$ .

To perform matrix calculations, like addition, subtraction, and multiplication, follow these simple commands.

To enter Matrix calculation, press  $\boxed{AC}$ .

To recall the name of a matrix, press  $\boxed{OPTN}$ .

To add A + B, press  $\boxed{3} \boxed{(MatA)} \boxed{+} \boxed{OPTN} \boxed{4} \boxed{(MatB)} \boxed{=}$ .

The solution matrix is displayed in the window and can be viewed without scrolling.

To calculate the determinant of the matrix, press

$\boxed{OPTN} \boxed{\nabla} \boxed{2} \boxed{(Determinant)} \boxed{OPTN} \boxed{3} \boxed{(MatA)} \boxed{)} \boxed{=}$ .

Matrices can be used to solve a system of equations.

Take the following equation with 3 unknowns:

$$\begin{cases} x + y = 3 \\ -x + 3y + 4z = -3 \\ 4y + 3z = 2 \end{cases}$$

Enter the coefficient matrix as Matrix A and the solution matrix as Matrix B.

MatB=  $\begin{bmatrix} 3 & -6 \\ 8 & 2 \end{bmatrix}$  2

1:Define Matrix  
2>Edit Matrix  
3:MatA 4:MatB  
5:MatC 6:MatD

MatA+MatB

MatAns=  $\begin{bmatrix} 4 & -4 \\ 5 & 6 \end{bmatrix}$  4

1:MatAns  
2:Determinant  
3:Transposition  
4:Identity

Det(MatA) 10

# MATRIX

Redefine the matrices by pressing **OPTN** **1**  
(Define Matrix).

Press **1** (MatA) to define Matrix A and enter the  
3 x 3 coefficient matrix.

Select the number of rows, **3** (Rows).

Select the number of columns, **3** (Columns).

Enter the values of the coefficients, pressing **⇐** after  
each one to move to the next value.

Now, enter the 3 x 1 solution matrix as Matrix B.

Press **OPTN** **1** (Define Matrix).

Define Matrix B **2** (MatB) as a 3 x 1, so select **3** (Rows)  
and **1** (Columns) from the next two windows.

```
1:Define Matrix
2:Edit Matrix
3:MatA      4:MatB
5:MatC      6:MatD
```

```
Define Matrix
1:MatA      2:MatB
3:MatC      4:MatD
```

```
MatA
Number of Rows?
Select 1~4
```

```
MatA
Number of
      Columns?
Select 1~4
```

```
MatA=
      D      E
[  1   1   0 ]
 [ -1  3   4 ]
 [  0  4   3 ]
                                     3
```

```
1:Define Matrix
2:Edit Matrix
3:Matrix Calc
```

```
Define Matrix
1:MatA      2:MatB
3:MatC      4:MatD
```

# MATRIX

Enter the values of the coefficients, pressing  $\boxed{=}$  after each one to move to the next value.

Press  $\boxed{AC}$  to return to the Matrix Calculation screen.

The solution can be found by calculating  $A^{-1} \times B$ .

Press  $\boxed{OPTN} \boxed{3}$  (MatA)  $\boxed{x^{-1}}$   $\boxed{\times}$   $\boxed{OPTN} \boxed{4}$  (MatB)  $\boxed{=}$ .

The solution represents the following:

$$\begin{cases} x = 1 \\ y = 2 \\ z = -2 \end{cases}$$

This same system can also be solved using the Equation icon.



# VECTOR

The **fx-991EX** is capable of handling vector calculations with vectors in 2 or 3 dimensions.

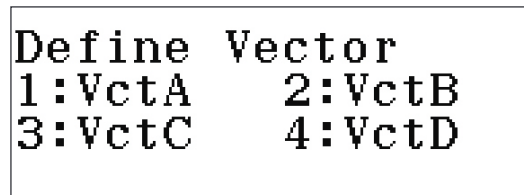
From the Main Menu, use the arrow keys to highlight the Vector icon and press  $\square$  or press  $\boxed{5}$ .



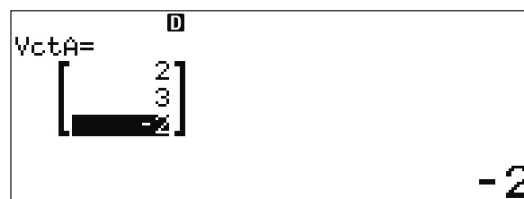
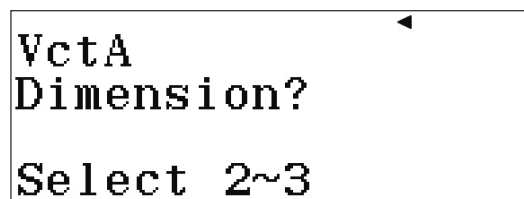
Let vectors **u** and **v** be defined in the 3-dimensional plane by the following:  $\mathbf{u} = 2\mathbf{i} + 3\mathbf{j} - 2\mathbf{k}$  and  $\mathbf{v} = 3\mathbf{i} - 4\mathbf{j} + 5\mathbf{k}$

Define **u** as Vector **A** with dimension 3.

Press  $\boxed{1}$  (VctA)  $\boxed{3}$  (Dimension).

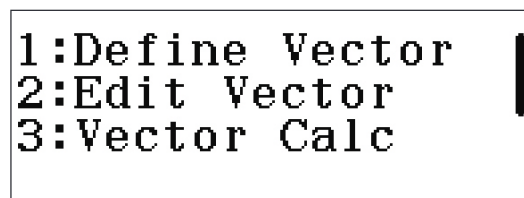


Enter the components of the vector and press  $\square$  after each one to move to the next value.

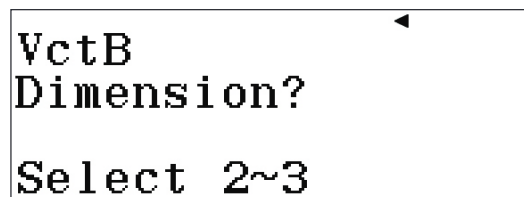


Define **v** as Vector **B** with dimension 3.

Press  $\boxed{\text{OPTN}}$   $\boxed{1}$  (Define Vector).



Press  $\boxed{2}$  (VctB)  $\boxed{3}$  (Dimension).



# VECTOR

Enter the components of the vector and press  $\boxed{\equiv}$  after each one to move to the next value.

To execute basic vector operations, press  $\boxed{\text{AC}}$  to enter Vector calculation.

Recall the names of the vectors and execute the desired operation by pressing  $\boxed{\text{OPTN}}$ .

Vector addition, subtractions, and multiplication are all available.

For subtraction, press  $\boxed{3}$  (VctA)  $\boxed{-}$   $\boxed{\text{OPTN}}$   $\boxed{4}$  (VctB)  $\boxed{\equiv}$ .

For multiplication, press

$\boxed{\text{OPTN}}$   $\boxed{3}$  (VctA)  $\boxed{\times}$   $\boxed{\text{OPTN}}$   $\boxed{4}$  (VctB)  $\boxed{\equiv}$ .

The sums of the product of the components of a vector are known as the vector's dot product. So,

$$\mathbf{u} \cdot \mathbf{v} = (2 * 3) + (3 * -4) + (-2 * 5) = -16.$$

Press  $\boxed{\text{OPTN}}$   $\boxed{3}$  (VctA)  $\boxed{\text{OPTN}}$   $\boxed{\nabla}$   $\boxed{2}$  (Dot Product)  $\boxed{\text{OPTN}}$   $\boxed{4}$  (VctB)  $\boxed{\equiv}$ .

$$\text{VctB} = \begin{bmatrix} 3 \\ -4 \\ 5 \end{bmatrix}$$

Vector

$$\text{VctA} - \text{VctB}$$

$$\text{VctAns} = \begin{bmatrix} -1 \\ 7 \\ -7 \end{bmatrix}$$

$$\text{VctAns} = \begin{bmatrix} 0 \\ -16 \\ -17 \end{bmatrix}$$

$$\text{VctA} \cdot \text{VctB}$$

# VECTOR

Even some very complex vector operations like the angle between vectors, which is defined as  $\cos^{-1} \frac{u \cdot v}{\|u\| \|v\|} = \theta$  in which  $\|v\| = \|2i + 3j - 2k\| = \sqrt{2^2 + 3^2 + (-2)^2} = |v|$  are easily accomplished on the **fx-991EX**.

To calculate vector cross product (not vector multiplication), press **OPTN** **▼** **3** (Angle) **OPTN** **3** (VctA) **SHIFT** **)** (,) **OPTN** **4** (VctB) **)** **=**.

**Angle<sup>D</sup>(VctA, VctB)**  
**123.2844165**

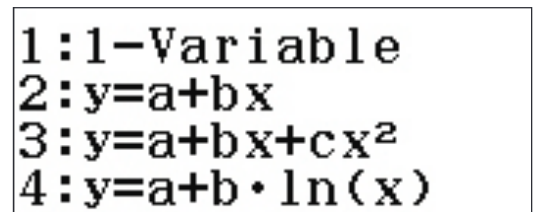
# STATISTICS

The **fx-991EX** can calculate several one-variable statistics, and also analyze relationships between two data sets using various regression models.

From the Main Menu, use the arrow keys to highlight the Statistics icon, then press  $\square$  or press **6**.



On the resulting menu, select **1** for "1-Variable" statistics.

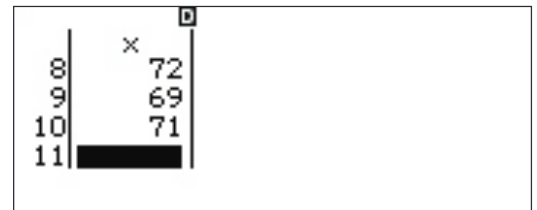
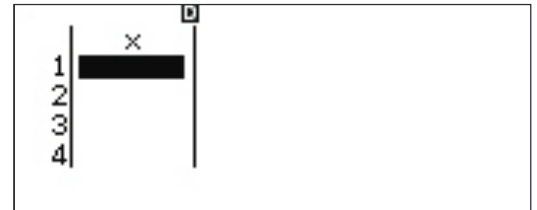


A data entry screen appears.

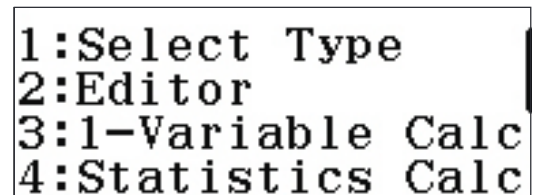
This example uses the following list of some students' heights, given in inches: 70.5, 74, 67, 71, 71, 72, 73.5, 72, 69, 71.

Enter data by typing in each value one at a time, with each followed by the  $\square$  key.

**7** **0** **.** **5**  $\square$ , **7** **4**  $\square$ , etc.



To calculate the 1-Variable statistics for this data set, press **OPTN** **3** (1-Variable Calc).



# STATISTICS

13 different 1-variable statistics have been calculated, 6 of which appear on the first screen. Press  $\blacktriangledown$  one or more times to reveal additional statistics:

```

 $\bar{x}$       =71.1
 $\Sigma x$    =711
 $\Sigma x^2$  =50589.5
 $\sigma^2 x$  =8.74
 $\sigma x$   =1.933907961
 $s^2 x$    =4.155555556
    
```

```

sx      =2.03851798
n       =10
min(x)  =67
Q1    =70.5
Med     =71
Q3    =72
    
```

```

max(x) =74
    
```

These statistics have each been stored inside the **fx-991EX** as variables, in case you should wish to use them in further calculations.

Press **AC** to return to the data entry screen.

```

      x
8 | 72
9 | 69
10| 71
11|
    
```

Enter the Option menu by pressing **OPTN**.

```

1:Select Type
2:Editor
3:1-Variable Calc
4:Statistics Calc
    
```

Select item **4** (Statistics Calc) to enter the Statistics calculation area.

```

Statistics
1-Variable
    
```

Press **OPTN**, and then the down arrow ( $\blacktriangledown$ ) once to reveal the different categories of statistical variables.

```

1:Summation
2:Variable
3:Min/Max
4:Norm Dist
    
```

For instance, to calculate the interquartile range (IQR), press **3** (Min/Max) **4** (Q<sub>3</sub>) **=** **OPTN**  $\blacktriangledown$  **3** (Min/Max) **2** (Q<sub>1</sub>) **=**.

```

1:min(x)  2:Q1
3:Med     4:Q3
5:max(x)
    
```

```

Q3-Q1
1.5
    
```

## FREQUENCY TABLES

If the data comes from a frequency table, ClassWiz can be set up to input the data values in one column, and the frequencies in another.

To access the set-up menu, press **SHIFT** **MENU** (SET UP).

Press the down arrow (**▼**) to reach the second page and **3** to select the Statistics settings.

Press **1** to turn the Frequency option **On**.

The Statistics Calculation area appears again. Even though nothing appears to have happened, the setting has indeed changed.

To access the Data entry area, press **OPTN** **3** (Data).

Notice a second column for frequencies now appears and the previous data set has been erased.

```
1:Input/Output
2:Angle Unit
3:Number Format
4:Engineer Symbol
```

```
1:Fraction Result
2:Complex
3:Statistics
4:Spreadsheet
```

```
Frequency?
1:On
2:Off
```

```
Q3-Q1D
1.5
```

```
1:Select Type
2:1-Variable Calc
3:Data
```

	$\times$	Freq
1		
2		
3		
4		

Enter the same 10 students' height used previously making use of the Frequency column. As each data point is inputted, ClassWiz automatically assigns a default Frequency of 1. Edit a Frequency by using the arrow keys to highlight it, then typing a new Frequency followed by  $\text{=}$ .

Once all of the data points (x) and frequencies (Freq) have been entered, press  $\text{OPTN}$   $\text{3}$  (1-Variable Calc) again to display the 1-Variable statistics.

	x	Freq
3	67	1
4	71	3
5	72	1
6		

	x	Freq
5	72	2
6	73.5	1
7	69	1
8		

(Notice, the statistics are identical to those previously found.)

$\bar{x}$	=71.1
$\sum x$	=711
$\sum x^2$	=50589.5
$\sigma^2 x$	=3.74
$\sigma x$	=1.933907961
$s^2 x$	=4.155555556

sx	=2.03851798
n	=10
min(x)	=67
Q <sub>1</sub>	=70.5
Med	=71
Q <sub>3</sub>	=72

max(x)	=74
--------	-----

## REGRESSIONS

To calculate a linear regression, press

$\text{OPTN}$   $\text{OPTN}$   $\text{1}$  (Select Type).

1:Select Type
2:Editor
3:1-Variable Calc
4:Statistics Calc

Select option  $\text{2}$  ( $y=a+bx$ ).

1:1-Variable
2: $y=a+bx$
3: $y=a+bx+cx^2$
4: $y=a+b \cdot \ln(x)$

A reminder that changing the type of statistics will clear previous data appears.

Press  $\text{=}$  to confirm and Clear memory.

Clear memory?	
[=]	:Yes
[AC]	:Cancel

# STATISTICS

Two columns for pairwise data (ordered pairs) now appears.

Note, the Frequency (Freq) column still appears; press

**SHIFT** **MENU** (SET UP) **▼** **3** (Statistics) **2** (Off)

to remove it.

Input the ordered pairs (1, 1), (2, 4), (3, 9), and (4, 16). Use the arrow keys to navigate to the “y” column as necessary.

To view 2-Variable statistics or the linear regression results, press **OPTN** **3**.

The 2-Variable statistics display calculation results for both x and y:

```

 $\bar{x}$       =2.5
 $\Sigma x$    =10
 $\Sigma x^2$   =30
 $\sigma^2 x$  =1.25
 $\sigma x$    =1.118033989
 $s^2 x$      =1.666666667
    
```

```

 $\sigma y$    =5.678908346
 $s^2 y$      =43
 $s y$        =6.557438524
 $\Sigma xy$     =100
 $\Sigma x^3$    =100
 $\Sigma x^2 y$  =354
    
```

	x	y	Freq
1			
2			
3			
4			

	x	y
2	2	4
3	3	9
4	4	16
5		

```

1:Select Type
2:Editor
3:2-Variable Calc
4:Regression Calc
    
```

```

sx      =1.290994449
n       =4
 $\bar{y}$      =7.5
 $\Sigma y$  =30
 $\Sigma y^2$  =354
 $\sigma^2 y$  =32.25
    
```

```

 $\Sigma x^4$  =354
min(x)    =1
max(x)    =4
min(y)    =1
max(y)    =16
    
```

Press **AC** **OPTN** **4** (Regression Calc) to display the linear regression results.

```

y=a+bx
a=-5
b=5
r=0.9843740387
    
```

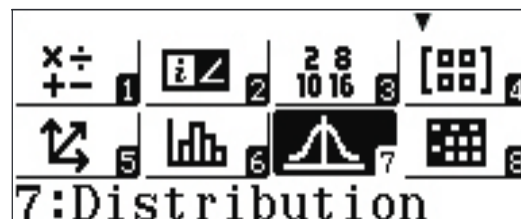
Other regressions, including quadratic, logarithmic, exponential, and geometric, can be accessed via **OPTN** **1** (Select Type).



# DISTRIBUTION

The **fx-991EX** can quickly generate probability distribution tables, covering the Normal, Inverse Normal, Binomial, and Poisson distributions.

From the Main Menu, use the arrow keys to highlight the Distribution icon, then press  $\square$  or press **7**.



Several distribution choices appear. Use  $\blacktriangledown$  to access the second page.

```
1:Normal PD
2:Normal CD
3:Inverse Normal
4:Binomial PD
```

```
1:Binomial CD
2:Poisson PD
3:Poisson CD
```

Select **1** (Binomial CD) from the second page to analyze the following Binomial Distribution problem: “A fair 6-sided die is rolled six times. Find  $P(6 \text{ comes up at least twice})$ .”

```
1:List
2:Variable
```

To enter the values of  $x$  (number of successes),  $N$  (number of trials), and  $p$  (probability of success), press **2** (Variable). Input the values as shown, using  $\square$  to create the fraction separator.

```
Binomial CD
x      :1
N      :6
p      :1/6
```

After pressing  $\square$  to input the value of  $p$ , ClassWiz automatically converts the fraction into a decimal for its own purposes.

Press  $\square$  again to calculate the probability.

```
Binomial CD
x      :1
N      :6
p      :0.1666
```

# DISTRIBUTION

A probability of 73.7% is displayed.

Because  $x = 1$  was entered, the calculator calculated  $P(\leq 1 \text{ six is rolled})$ . This provides a great opportunity to use the **complement** of an event:  $P = 1 - 0.737 = 0.263 = 26.3\%$ .

To display the probabilities of obtaining *any* number of sixes in 6 rolls, press **OPTN** **1** (Select Type).

This time, choose **4** (Binomial PD).

Because the calculation is for probabilities for several different numbers of successes, select **1** (List).

Enter the values 0, 1, 2, 3, 4, 5, and 6 into the "x" column (which represents number of successes). Press **≡** after each input.

Once the final value has been entered, press **≡** again to end the data entry process.

Notice, the values of  $N$  and  $p$  are preserved from the cumulative probability calculation. ( $N$  and  $p$  are global calculator variables.)

P= 0.736775549

1:Select Type

1:Normal PD  
2:Normal CD  
3:Inverse Normal  
4:Binomial PD

1>List  
2:Variable

	x	P
1		
2		
3		
4		

Binomial PD

	x	P
5	4	
6	5	
7	6	
8		

Binomial PD

Binomial PD	
N	:6
p	:0.1666

# DISTRIBUTION

Press **☰** one more time to calculate the probability distribution table.

Notice how the small probabilities are expressed in proper scientific notation!

## INVERSE NORMAL

To calculate an Inverse Normal Distribution, press **OPTN** **1** (Select Type).

("Editor" edits the previous PD's data list.)

Select **3** (Inverse Normal).

Input the values as shown to answer the question: "If the heights of U.S. males are normally distributed with a mean of 70 inches and a standard deviation of 4 inches, what range defines the tallest 10% of U.S. males?"

Press **☰** once more to reveal the result. To be in the top 10% of U.S. males by height, a man must be over 75 inches (6'3") tall.

		$\sigma$	P	Binomial
1	$\times$	0	0.3348	PD
2		1	0.4018	
3		2	0.2009	
4		3	0.0535	

		$\sigma$	P	Binomial
5	$\times$	4	$8 \times 10^{-8}$	PD
6		5	$6.4 \times 10^{-4}$	
7		6	$2.1 \times 10^{-5}$	
8				

```
1:Select Type
2:Editor
```

```
1:Normal PD
2:Normal CD
3:Inverse Normal
4:Binomial PD
```

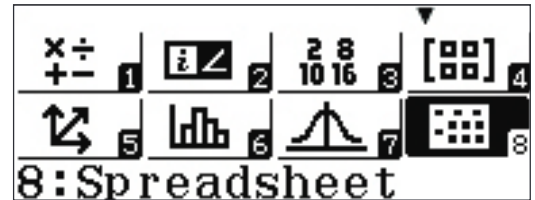
```
Inverse Normal
Area :0.9
σ :4
μ :70
```

```
xInv=
75.12620655
```

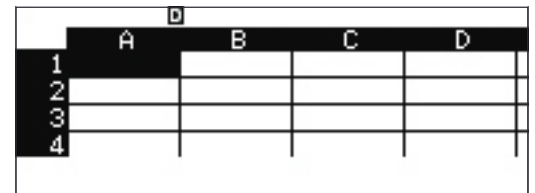
# SPREADSHEET

The Spreadsheet mode is useful for studying the statistics of data that require more than two lists. It also supports recursive formulas, sequences, and series.

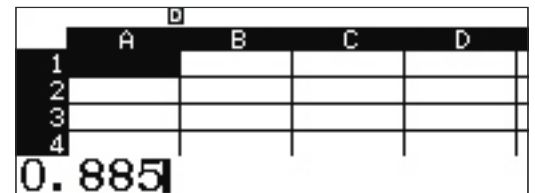
From the Main Menu, use the arrow keys to highlight the Spreadsheet icon, then press **≡** or press **8**.



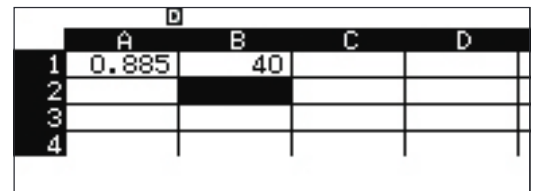
The ClassWiz spreadsheet looks and acts similarly to many popular software spreadsheet applications.



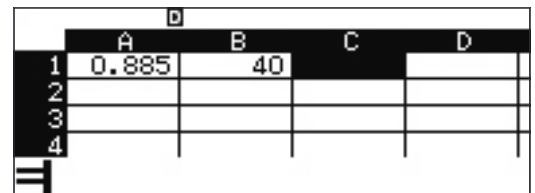
Investigate the mass of different common sizes of laundry detergent bottles, when the average density of liquid laundry detergent is 0.885 g/mL. Type **0** **.** **8** **8** **5** **≡** in cell **A1**.



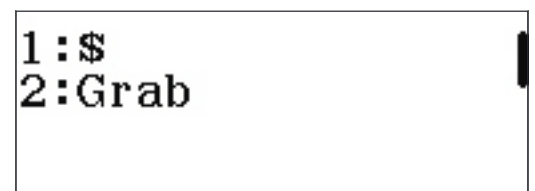
Use the arrow keys to move over to cell **B1**, and input **4** **0** **≡** to represent a 40 fl oz. (1 fl oz. = 29.5735 mL) bottle of laundry detergent.



Move to cell **C1**, and press **ALPHA** **CALC** (=) to create an equals sign. Like in other spreadsheet programs, this is the first step necessary when entering a formula.



To “grab” the value within a cell, press **OPTN** **2** (Grab).



# SPREADSHEET

Navigate to cell **B1**, and press **⏏** (Set) to **Grab** the value in that cell.

	A	B	C	D
1	0.885	40		
2				
3				
4				

Set : [=]

This places a reference to cell **B1** within the formula.

	A	B	C	D
1	0.885	40		
2				
3				
4				

=B1|

To create a conversion from fluid ounces (fl oz.) to milliliters (mL), type **ⓧ 2 9 . 5 7 3 5 ⏏**.

	A	B	C	D
1	0.885	40		
2				
3				
4				

=B1×29.5735|

The formula has correctly calculated that a 40 fl oz. bottle of laundry detergent has a volume of 1182.9 mL.

	A	B	C	D
1	0.885	40	1182.9	
2				
3				
4				

Formulas can also be typed directly, without using the **Grab** command.

Navigate to cell **D1** and input **ⓧ ⓧ ⓧ (=)**

**ⓧ ⓧ (A) 1 ⓧ ⓧ ⓧ (C) 1 ⏏**.

	A	B	C	D
1	0.885	40	1182.9	
2				
3				
4				

=A1×C1|

A 40 fl oz. (1182.9 mL) bottle of laundry detergent has a mass of 1046.9 grams.

	A	B	C	D
1	0.885	40	1182.9	1046.9
2				
3				
4				

Now, let's use the power of relational formulas to check some other bottle sizes:

To populate many different cells with the same value, press

**ⓧ 2** (Fill Value).

1:Fill	Formula
2:Fill	Value
3:Edit	Cell
4:Free	Space

Input the density of laundry detergent as the **Value** and **A2:A6** as the cell **Range**. Press **ALPHA** **(←)** **(A)** **2** **ALPHA** **(=)** **(:)** **ALPHA** **(←)** **(A)** **6** **=** **=**.

```
Fill Value
Value :0.885
Range :A2:A6
```

Column **A** is now filled with the density value.

	A	B	C	D
1	0.885	40	1182.9	1046.9
2	0.885			
3	0.885			
4	0.885			

Next populate column **B** with additional bottle sizes.

Navigate to cell **B2**, and input the value 75 by pressing **7** **5** **=**.

	A	B	C	D
1	0.885	40	1182.9	1046.9
2	0.885	75		
3	0.885			
4	0.885			

To populate many different cells with the same formula, press **OPTN** **1** (Fill Formula).

```
1:Fill Formula
2:Fill Value
3>Edit Cell
4:Free Space
```

Input the formula **ALPHA** **(=)** **(B)** **2** **+** **25** **=**.

```
Fill Formula
Form =B2+25
Range :B3:B3
```

Notice, the cell **Range** is pre-populated with the currently highlighted cell (**B3**).

Use the right arrow to edit only the end cell by pressing **▶▶▶▶▶▶** **DEL** **6** **=** **=**.

```
Fill Formula
Form =B2+25
Range :B3:B6
```

Scroll down to cell **B6** to make sure that the formula has been adjusted relative to each cell's position, so that cells **B2** to **B6** now display bottle sizes from 75 to 175 fl oz. (1 fl oz. = 29.5735 mL).

	A	B	C	D
3	0.885	100		
4	0.885	125		
5	0.885	150		
6	0.885	175		

=B5+25

# SPREADSHEET

Navigate to cell **C1**, which still displays the formula used to convert fluid ounces to milliliters.

The ClassWiz has a “copy and paste” option that can be used instead of retyping the same formula repeatedly.

Press **OPTN** **▼** **2** (Copy & Paste).

The formula from the currently highlighted cell (**C1**) has now been copied.

Scroll down one cell at a time (**▼** **≡**) to **Paste** this formula into cells **C2** through **C6**.

Column **C** now contains the volumes, in milliliters, of the different sizes of laundry detergent bottles.

To exit **Copy & Paste** mode, press **AC**.

Time to practice! Use the same technique to **Copy & Paste** the mass calculation formula from cell **D1** into cells **D2** through **D6**.

If done correctly, Column **D** should show masses (in grams) as shown.

So, for example, a 175 fl oz. (5175.3 mL) bottle of laundry detergent has a mass of about 4.5 kg.

A decent amount of data has been entered now. To check how much free space remains in ClassWiz’s memory, press **OPTN** **4** (Free Space).

	A	B	C	D
1	0.885	40	1182.9	1046.9
2	0.885	75		
3	0.885	100		
4	0.885	125		

**=B1×29.5735**

1:Cut & Paste  
2:Copy & Paste  
3>Delete All  
4:Recalculate

	A	B	C	D
1	0.885	40	1182.9	1046.9
2	0.885	75		
3	0.885	100		
4	0.885	125		

**Paste: [=]**

	A	B	C	D
3	0.885	100	2957.3	
4	0.885	125	3696.6	
5	0.885	150	4436	
6	0.885	175	5175.3	

**Paste: [=]**

	A	B	C	D
1	0.885	40	1182.9	1046.9
2	0.885	75	2218	
3	0.885	100	2957.3	
4	0.885	125	3696.6	

**=A1×C1**

	A	B	C	D
3	0.885	100	2957.3	2617.2
4	0.885	125	3696.6	3271.5
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1

**=A6×C6**

1:Fill Formula  
2:Fill Value  
3>Edit Cell  
4:Free Space

1318 Bytes of memory remain as free space.

Numerical values require 10 Bytes each, while formulas require 17+ Bytes each.

Determine the average capacity of the different bottles of laundry detergent.

Navigate to cell **B7**, and press **OPTN**.

Scroll down three pages (⏮ ⏮ ⏮), and select **3** (Mean).

Type in the cell range of the average **ALPHA** **□□□** (B) **1** **ALPHA** **□□□** (:)  
**ALPHA** **□□□** (B) **6** **)** **=**.

The average capacity is 110.83 fluid ounces.

If one of each of these bottles was purchased, what is the total weight of laundry detergent purchased that would be placed in a car?

Navigate to cell **D7**, and press **OPTN**.

Return again to the summary statistics calculation screen (⏮ ⏮ ⏮) and select **4** (Sum).

1318 Bytes Free

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7				
8				

1:Min  
2:Max  
3:Mean  
4:Sum

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7				
8				

Mean(B1:B6)

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		
8				

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		
8				

1:Min  
2:Max  
3:Mean  
4:Sum



# SPREADSHEET

Use the **Grab** command rather than typing the locations of the cells in the cell range.

Press **OPTN** **2** (Grab).

Scroll up to cell **D1**, and **Set** it as the object to be Grabbed by pressing **≡**.

Use **ALPHA** **⏏** (:) to type a colon.

Grab cell **D6** as the ending cell in the cell range by pressing **OPTN** **2** **▲** **≡**.

Close the parentheses (**)**), and press **≡** to calculate the sum of the masses in cells **D1** through **D6**.

The bottles would have a total mass of 17404 grams, or about 17.4 kilograms.

But this is a mass, not a weight!

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		
8				

Sum (|

1 : \$  
2 : Grab

	A	B	C	D
1	0.885	40	1182.9	1046.9
2	0.885	75	2218	1962.9
3	0.885	100	2957.3	2617.2
4	0.885	125	3696.6	3271.5

Set : [=]

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		
8				

Sum (D1 :|

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		
8				

Set : [=]

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		
8				

Sum (D1 : D6)|

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				

This is one example of the powerful ways in which various features of the **fx-991EX** can be combined.

Begin entering the formula as shown into cell **D8** by pressing

**[ALPHA] [CALC] (=) [ALPHA] [sin] (D) [7]**.

Press **[SHIFT] [8] (CONV)** to access the Conversion menu.

Select **[4] (Mass)**.

Choose mass conversion **[4] (kg ► lb)**.

This will convert the mass from cell **D7**, which is currently in kilograms, into pounds.

Press **[=]**, and *Voila!*

Even ClassWiz's powerful Conversion feature can be used within the Spreadsheet module. But wait... 38 thousand pounds?!?

17404 grams needs to be converted into kilograms.

With cell **D8** highlighted, press **[OPTN] [3] (Edit Cell)**.

A cursor appears in the previously entered formula, allowing it to be edited.

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				

=D7

```

1:Length
2:Area
3:Volume
4:Mass
    
```

```

1:oz►g      2:g►oz
3:lb►kg     4:kg►lb
    
```

	A	B	C	D
5	0.885	150	4436	3925.8
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				

=D7kg ► lb

	A	B	C	D
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				38370
9				

=D7kg ► lb

```

1:Fill Formula
2:Fill Value
3>Edit Cell
4:Free Space
    
```

	A	B	C	D
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				38370
9				

=D7kg ► lb

# SPREADSHEET

Use the right arrow key (➡) to move within the formula, inserting parentheses and a factor-of-1000 adjustment as shown. Press ➡ ⌂ ➡ ➡ ➡ ÷ 1 0 0 0 ⌂ =.

Phew! That's better. The car is no longer carrying 19+ tons of laundry detergent home. The actual total weight is a much more reasonable 38 pounds.

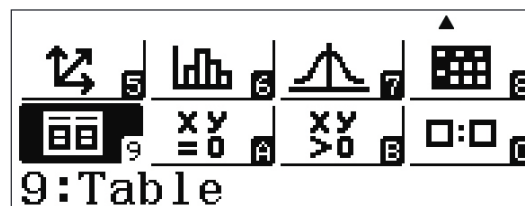
	A	B	C	D
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				38370
9	=(D7÷1000)kg➡lb			

	A	B	C	D
6	0.885	175	5175.3	4580.1
7		110.83		17404
8				38.37
9				

# TABLE

The Table feature on the **fx-991EX** is a powerful way to solve a single function or two functions simultaneously. The table range and step is easily customizable.

From the Main Menu, use the arrow keys to highlight the Table icon and press  $\boxed{\equiv}$  or press  $\boxed{9}$ .

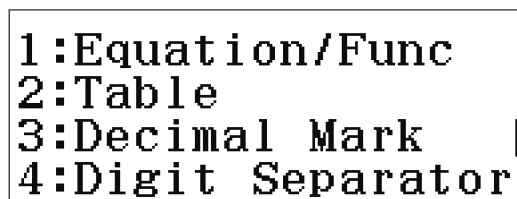


To change the setup of the table to generate a table with only one function, press  $\boxed{\text{SHIFT}}$   $\boxed{\text{MENU}}$  (SET UP).

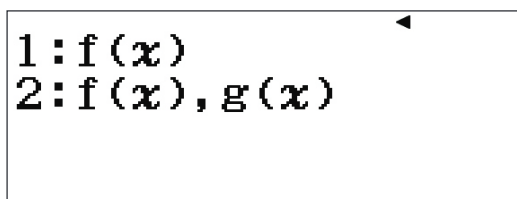


Use the down arrow key to view the menu option for Table; it will be the 3rd screen.

Press  $\boxed{2}$  (Table) to choose the number of functions used in the table.

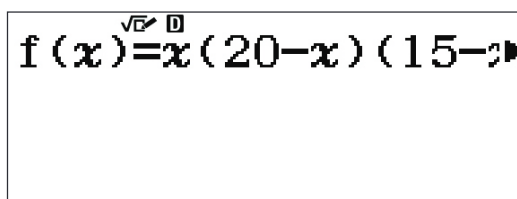


Press  $\boxed{1}$  (f(x)) to generate a table with only one function as an input.

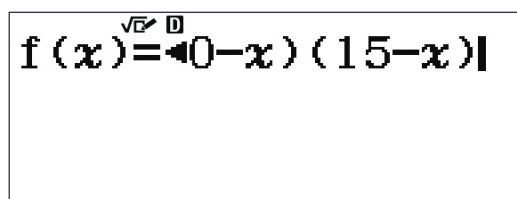


Consider the classic volume of a box problem. What is the maximum volume of a box made from a 20x15 sheet of cardboard by removing squares from each corner?

The function that represents the volume of the box is  $f(x) = x(20-x)(15-x)$ .



To enter this function, press  $\boxed{x}$   $\boxed{(}$   $\boxed{2}$   $\boxed{0}$   $\boxed{-}$   $\boxed{x}$   $\boxed{)}$   $\boxed{(}$   $\boxed{1}$   $\boxed{5}$   $\boxed{-}$   $\boxed{x}$   $\boxed{)}$   $\boxed{\equiv}$ .



# TABLE

To set the range from 1 to 7 and the step at 1, press

**1** **=** **7** **=** **1** **=**.

Press **=** to view the table.

Use the arrow keys to scroll through the values.

The maximum value appears to be between 5 and 6.

To refine the search, enter a new value in any place in the table.

For example, at line 8, press **6** **.** **5** **=**.

To enter a value one-step greater than the previous value, press **+**.

To enter a value one-step less than the previous value, press **-**.

To change the step value or change the start and end values of the table, press **AC** **=**.

Enter the new values and press **=** to view the table.

Use the arrow keys to scroll to the value that gives the maximum volume.

Table Range		
Start:	1	
End:	7	
Step:	1	

Table Range		
x	f(x)	
1	266	
2	468	
3	612	
4	704	

Table Range		
x	f(x)	
4	704	
5	750	
6	756	
7	728	

Table Range		
x	f(x)	
7	728	
8	745.87	
9	757.62	
10		

Table Range		
x	f(x)	
8	745.87	
9	757.62	
10	745.87	
11	703.12	

Table Range		
Start:	5.1	
End:	6.5	
Step:	0.1	

Table Range		
x	f(x)	
1	752.3	
2	754.2	
3	755.72	
4	756.86	

# TABLE

The maximum volume calculated to one decimal place appears at 5.7 inches.

$x$	$f(x)$
5.5	757.62
5.6	758.01
5.7	758.04
5.8	757.71

5.8

Consider the following two functions  $\begin{cases} f(x) = x^3 - 7x + 6 \\ g(x) = x^2 - 3x + 2 \end{cases}$

Find the roots of the equations and points of intersection, as well as the end behavior of each function.

Press **SHIFT** **MENU** (SET UP) and use the down arrow key to view the menu option for Table. Press **2** (Table) to choose the number of functions used in the table.

```
1:Equation/Func
2:Table
3:Decimal Mark
4:Digit Separator
```

Press **2** (f(x),g(x)) to generate a table with two function as inputs.

$$\begin{array}{l} 1: f(x) \\ 2: f(x), g(x) \end{array}$$

Enter the first function as  $f(x)$  by pressing  $\boxed{x} \boxed{x^{\square}} \boxed{3} \boxed{\rightarrow} \boxed{-}$   
 $\boxed{7} \boxed{x} \boxed{+} \boxed{6} \boxed{=}$ .

$$f(x) = x^3 - 7x + 6$$

If there is already a function present, press **AC** to clear the previous function.


Enter the second function as  $g(x)$  by pressing  $\boxed{x}$   $\boxed{x^2}$   $\boxed{-}$   $\boxed{3}$   $\boxed{x}$   $\boxed{+}$   $\boxed{2}$   $\boxed{=}$ .

$$g(x) = x^2 - 3x + 2$$

Create a table that has a domain of -5 to 5 with step of 1.

Table	Range
Start	-5
End	5
Step	1


# TABLE

Press  to view the table.


Based on the information from the table, it appears  $f(x)$  goes to negative infinity to the left and  $g(x)$  goes to positive infinity to the left.

There appears to be roots of 1 and 2 for both functions.  
To determine the behavior between roots, type in a number between 1 and 2, like 1.5.

The right end behavior for both functions appears to be increasing towards positive infinity.

			
$x$		$f(x)$	$g(x)$
1	-3	-84	42
2	-4	-30	30
3	-3	0	20
4	-2	12	12

-5

			
$x$		$f(x)$	$g(x)$
7	1	0	0
8	2	0	0
9	1.5	-1.125	-0.25
10	4	42	6

4

The **fx-991EX** numerically solves equations elegantly. It is accomplished with the help of the Natural Textbook Display™ in the Equation/Func mode. The Equation/Func mode uses Newton's method to find solutions to equations. The **fx-991EX** has the power to handle Simultaneous Equations with up to 4 unknowns and Polynomial Equations up to the 4th degree.

## SIMULTANEOUS EQUATIONS

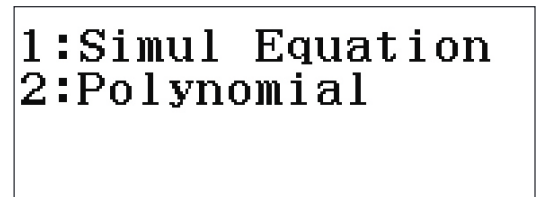
From the Main Menu, use the arrow keys to highlight the Equation/Func icon and press  $\boxed{\equiv}$  or press  $\boxed{\rightarrow}$  (A).



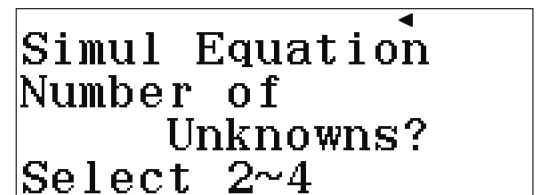
To solve the following system of simultaneous equations

$$\begin{cases} 2x + y = 5 \\ -4x + 6y = 12 \end{cases}$$

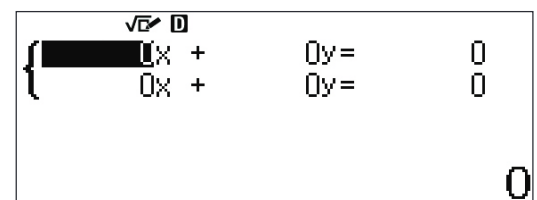
select  $\boxed{1}$  (Simul Equation).



Choose the number of Unknowns. For this example, press  $\boxed{2}$  (Unknowns).

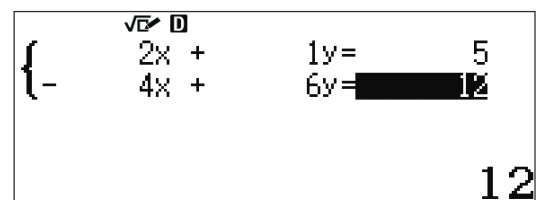


A 2x2 system of equations template is displayed. The template is in  $Ax + BY = C$  form in which A, B and C can be any value. For fractional values, use the  $\boxed{\frac{\Box}{\Box}}$  key.



Type in each value followed by the  $\boxed{\equiv}$  key.

Press  $\boxed{2} \boxed{\equiv} \boxed{1} \boxed{\equiv}$ , etc.





# EQUATION/FUNC

To solve, press  $\boxed{\text{=}}$  and use the arrow keys ( $\blacktriangledown$   $\blacktriangle$ ) to toggle between solutions.

$$x = \frac{9}{8}$$

The solutions are shown in natural display format. For decimal approximations, press  $\boxed{\text{S}\rightarrow\text{D}}$ .

$$y = \frac{11}{4}$$

To change the values in the system of equations without changing the type of equation or system, press  $\boxed{\text{AC}}$ .

$$\begin{cases} 2x + 1y = 5 \\ 4x + 6y = 12 \end{cases}$$

To change the type of equation or system size, press  $\boxed{\text{OPTN}}$  and select from the on-screen menus.

1: Simul Equation  
2: Polynomial

Simul Equation  
Number of  
Unknowns?  
Select 2~4

$$\begin{cases} 0x + 0y = 0 \\ 0x + 0y = 0 \end{cases}$$

The **fx-991EX** also solves inconsistent systems, both independent and dependent. Enter the displayed inconsistent and independent system

$$\begin{cases} 2x + 3y = 6 \\ 2x + 3y = 5 \end{cases}$$

Press  $\boxed{\text{=}}$  to see the solution.

No Solution

Enter the displayed inconsistent dependent system.

$$\begin{cases} 2x + 3y = 6 \\ 4x + 6y = 12 \end{cases}$$

Press  $\equiv$  to see the solution.

Infinite Solution

To input a larger system of simultaneous equation

$$\begin{cases} 1x + 1y + 1z = 9 \\ 3x + 2y - 1z = 8 \\ 3x + 1y + 2z = 1 \end{cases}$$

press  $\text{OPTN}$   $\text{1}$  (Simul Equation)  $\text{3}$  (Unknowns).

$$\begin{cases} 1y + 1z = 9 \\ 2y - 1z = 8 \\ 1y + 2z = 1 \end{cases}$$

Enter the coefficients for each equation and press  $\equiv$  to solve.

$x = -\frac{34}{7}$

$y = \frac{85}{7}$

$z = \frac{12}{7}$

## POLYNOMIAL EQUATIONS

The **fx-991EX** has the computing power to solve polynomial equations up to 4th degree.

To start solving polynomial equations, in the Equation/Func icon, press **OPTN** **2** (Polynomial).

1:Simul Equation  
2:Polynomial

Select the degree of the polynomial. For this example, use a 3rd degree polynomial. Press **3** (Degree).

Polynomial  
Degree?  
Select 2~4

Fill out the template for a 3rd degree polynomial. Type in each coefficient followed by the **=** key.

$ax^3+bx^2+cx+d$   
+ 0  $0x^2+$   $0x$   
0

$$x^3 + 4x^2 + x - 6 = 0$$

Press **=** to solve the equation.

$ax^3+bx^2+cx+d$   
1  $x^3+$   $4x^2+$   $1x$   
- 6  
-6

Use the arrow keys (**▲** **▼**) to toggle through the solutions.

$ax^3+bx^2+cx+d=0$   
 $x_1=$   
1

$ax^3+bx^2+cx+d=0$   
 $x_2=$   
-2

$ax^3+bx^2+cx+d=0$   
 $x_3=$   
-3

The **fx-991EX** has the power to solve polynomials in the complex plane.

Press **OPTN** and change the type of polynomial to quadratic (**2**).

Enter the coefficients that appear in the displayed screen into the quadratic template, and press **=**.

The solutions are displayed in simplified radical form including the imaginary unit.

Press **▼** to see the second imaginary solution.

Polynomial  
Degree?

Select 2~4

$$ax^2+bx+c$$

$\sqrt{\square}$   $\square$   $i$

$\blacksquare 1x^2 + 2x + 3$

1

$$ax^2+bx+c=0$$

$\sqrt{\square}$   $\square$   $i$  ▼

$x_1 =$

$-1 + \sqrt{2}i$

$$ax^2+bx+c=0$$

$\sqrt{\square}$   $\square$   $i$  ▼▲

$x_2 =$

$-1 - \sqrt{2}i$

# INEQUALITY

Solving polynomial inequalities has never been easier.

From the Main Menu, use the arrow keys to highlight the Inequality icon and press  $\equiv$  or press  $\equiv$  (B).

Enter the degree of the polynomial inequality, in this case,  $\boxed{3}$  (Degree).

Choose the form of the inequality. Press  $\boxed{2}$   
 ( $ax^3 + bx^2 + cx + d < 0$ ).

Enter the coefficients of the polynomial, as shown.  
 Press  $\boxed{1} \equiv \boxed{4} \equiv \boxed{1} \equiv \boxed{-} \boxed{6} \equiv$ .

Press  $\equiv$  to see the solutions.

Notice, the form of the inequality is written  
 as  $x < a, b < x < c$ .

If the solution runs off the screen, use the left and right ( $\blacktriangleleft$   $\blacktriangleright$ )  
 arrow keys to see the entire solution.



Polynomial  
Degree?  
Select 2~4

1:  $ax^3+bx^2+cx+d>0$   
 2:  $ax^3+bx^2+cx+d<0$   
 3:  $ax^3+bx^2+cx+d\geq 0$   
 4:  $ax^3+bx^2+cx+d\leq 0$

$ax^3+bx^2+cx+d<0$   
 $1x^3+4x^2+1x-6 < 0$

$x < a, b < x < c$   
 $x < -3, -2 < x < 1$

## NOTES

[illegible]

# NOTES

[illegible]



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